SCOTTISH EDUCATION DEPARTMENT

SCIENCE

IN SECONDARY SCHOOLS

371·3
S425

EDINBURGH
HIS MAJESTY'S STATIONERY OFFICE
1951
NINEPENCE NET

SCOTTISH EDUCATION DEPARTMENT

Psy

SCIENCE
in Secondary Schools

(FIRST THREE YEARS)

DAVID HARE TRAINING COLLEGE * LIBRARY *
121
12086
6.2.52

371.38
S425

EDINBURGH: HIS MAJESTY'S STATIONERY OFFICE
1951

Contents

Page
AIMS AND SCOPE 3
METHOD 5
 RECORDING OF EXPERIMENTS 6
 AIDS AND ACTIVITIES 7
SYLLABUS 8
 PHYSICS 8
 CHEMISTRY 9
 BIOLOGY 9
 NOTES ON THE SYLLABUS 9
SCIENCE AND THE BACKWARD PUPIL 11

Bureau Edn. Psy. Research
DAVID HARE TRAINING COLLEGE
Dated 6. 2. 52
Accs. No. 121

DAVID HARE TRAINING COLLEGE * LIBRARY *

SCIENCE
IN SECONDARY SCHOOLS

(FIRST THREE YEARS)

Aims and Scope of Course

The purpose of teaching science is to give the pupil some understanding of the structure of his material environment and to show how such an understanding enables man, on the one hand, to adapt himself better to that environment, and, on the other, to mould it to meet his needs. To achieve this purpose the school should give the pupil:

(i) some familiarity with scientific method;
(ii) a co-ordinated body of scientific knowledge.

At a very early age the child begins to acquire habits of observation and to connect cause and effect. The extent to which his interests and powers of observation develop depends on his native endowment and on the opportunities and the encouragement he has had at home and in the primary school.

In the secondary school the science course sets out to provide controlled experiences whereby the pupil obtains a more definite training in scientific method. From observations made during experiments he learns to formulate conclusions and gradually comes to appreciate (*a*) how particular conclusions can be combined in a general statement—a hypothesis which may, after much further testing, become a law—and (*b*) how these conclusions may be used to explain familiar phenomena and how they have been applied in industry and elsewhere. He is thus being trained in the inductive and deductive methods of science. Limitations of time make it impossible to give the pupil much practical experience in the rigorous application of the inductive method, but this difficulty can be partially overcome in two ways.

(i) When it is desired to pass from the particular statement which summarizes the findings of one experiment to the more general statement of a scientific law, the teacher should provide the conclusions from other experiments which help to establish the law.

(ii) The different members of a class may conduct related experiments the results of which will lead to the formulation of a general statement. It takes no more time, for example, for a number of groups in a class to test the green leaves of different plants for starch than it does for all groups to test the green leaves of one plant. This procedure not only saves time but may also serve to emphasize the danger of hasty generalization, for example, in the study of the reactions between metals and acids.

With the enormously wide and successful applications of physics and chemistry in the nineteenth century, emphasis both in research and in teaching was naturally laid on these sciences. In recent years, however, biology and its many applications have assumed an equal importance, and there has also been a growing appreciation of the unity of science. Teaching practice should reflect these developments. The subject matter should be drawn mainly from physics, chemistry, and biology, the several branches being co-ordinated as far as possible. Local conditions and interests may suggest the inclusion of other branches such as geology and astronomy. At each stage the study of everyday applications of scientific principles should constitute an important feature. A course on these lines, leading to some understanding of natural phenomena and of the ways in which man has applied his scientific knowledge, and to some study of man as a physical organism, would meet the educational requirements of all pupils.

Method

The depth of treatment will depend largely on the abilities of the pupils. For example, one class might decompose water by calcium, magnesium, and electrolysis, whereas another, of less able pupils, might use only electrolysis. In both classes the pupils should realize that water is a compound of hydrogen and oxygen, but the abler pupils would have had a more rigorous training. (See 'Science and the Backward Pupil', page 11).

Experiments must form the basis of science teaching, and wherever practicable they should be performed by the pupils themselves. There is no adequate substitute for this individual practical work. For many it is a most important method of intellectual training and to all it affords first-hand experience of various aspects of scientific method.

If it is to yield its fullest value, all experimental work must be pervaded by a real spirit of research. Thus:

(i) every experiment should have a definite aim appreciated by the pupils—the statement of this aim should not anticipate the result of the experiment;

(ii) the pupils should be led to take an active part in the planning of the experiment, or series of experiments, and in the selection of appropriate apparatus;

(iii) the details of all experiments should be such that the work can be carried through with confidence and with good prospect of success;

(iv) no experiment which is intended for individual work should be demonstrated in full—demonstration of correct technique may be needed, but to divulge the result of the experiment robs the exercise of most of its value and tends to reduce laboratory work to a mere manipulation of apparatus.

In general, qualitative experiments are more likely to stimulate thought in the beginner, and are much more economical of time than quantitative experiments.

Although individual experimental work has great value it makes heavy demands on time and its exclusive use would inevitably narrow the scope of the course. There is a place for demonstration lessons, but these must be carefully planned and they should set a high standard of technique. They retain the experimental approach and may, on occasion, provide the most effective means of presentation. For example, some topics may well be introduced by spectacular experiments, which have an appeal no teacher can afford to neglect. Revision may, on occasion, be supplemented by a demonstration lesson consisting of a series of small experiments. For experiments which are dangerous, or which require apparatus too costly to purchase in sufficient quantity for pupils to use, or which demand dexterity beyond the capability of the pupils, demonstration must be employed.

Lectures and illustrated talks are valuable means of bringing before the pupils such matters as the development of a scientific theory, outstanding achievements by scientists, and some of the industrial applications of science.

Biology has a special contribution to make in illustrating techniques not common in the physical sciences—for example, in the setting up of controls. The essential unity of plant and animal life and their interdependence should be stressed. The teaching should also be so directed that a natural and important place is found for a study of the functioning of the human body. Inculcation of the principles of physical fitness and healthy living should be kept in mind throughout, and the responsibility of the individual towards himself and the community in maintaining good standards of hygiene should be emphasized.

Great importance should be attached to the applications of scientific principles. Not only have they inherent interest and significance, but they also give point to the study of science and provide further opportunities for exercises in 'cause and effect'. Whenever possible, actual appliances should be used. These may be supplemented by diagrams or sketches, but even with able pupils particular care is necessary to ensure that such drawings are correctly interpreted. Consideration of several applications of a scientific principle may make an interesting introduction to the study of the principle itself; for example, the examination of sirens, drums, mouth-organs, and vibrating stretched elastic might lead up to a lesson on the production of sound.

There is a definite place for the wise use of numerical exercises, but these should be chosen primarily for the light they throw on the topics under consideration; on no account should they be mere tests of mathematical ingenuity.

Recording of Experiments

The power to state facts in a concise manner, free from extraneous matter, is invaluable in all walks of life. By training pupils to make reports in both oral and written form, science teachers play an important part in the general education of the children. Any pupil who can write a simple sentence is ready to be trained to record experiments, and this training should begin at the start of the course. Even in the first year, most pupils should, after a short period of training, be able to write their own reports of the simpler experiments. Reports should state clearly:

(i) what was done,
(ii) what was observed,
(iii) what was learned from the results.

(i) and (ii) should be written down as the experiment proceeds; (iii), if simple, may be written at once, but usually will be recorded only after some discussion. Full use should be made of annotated diagrams. The information thus conveyed should not be duplicated in a written description.

Dictated or copied notes produce a passive attitude both in performing the experiment and in writing the report. Habitual use of this method cannot be justified.

Aids and Activities in the Teaching of Science

Illustrations and models often give greater point to a lesson, and indeed their use is indispensable in some instances, e.g., when the material under consideration is not suitable for class use or cannot be procured. Permanent display is seldom advisable.

The film-strip projector has made available in very convenient form a rich source of illustrative material. More useful for some purposes is the cinematograph projector. This is especially true in biology, where it is sometimes very desirable to depict movement. Valuable as the newer aids undoubtedly are, it should never be forgotten that they are only tools in the hands of the teacher; as with all tools, skill and discretion are essential if they are to be used to good advantage.

Much can be done to stimulate and maintain interest by having available to the pupils a wide range of scientific literature of a simple and attractive sort. A stock of elementary reference books is also desirable.

Organized visits arranged to show pupils applications of science to industry can make a real contribution to their training. Careful planning, however, is essential. It is often advantageous to give the pupils a general outline of what they will see and of the features they should especially look for. Fruitful discussion should be the normal outcome of a successful visit.

Much can be accomplished with the co-operation of curators of museums, e.g., special displays may be arranged or specimens may be loaned for exhibition in school.

Broadcast lessons frequently employ resources which are not normally available to schools, and can make a strong appeal to children. If full benefit is to be derived from such lessons, preparation and follow-up are essential, and use should be made of the pamphlets published in connection with the talks. If difficulties of organization make it impracticable to take a complete series, it should be remembered that the lessons are to some extent self-contained, and individual broadcasts may be selected from time to time for use with appropriate classes.

Science courses may develop and foster interest in a wide variety of activities such as model-making, wireless and the keeping of aquaria and vivaria. The teacher who can assist in laying the foundations of leisure-time interests in such pursuits will render invaluable service to the pupils.

Syllabus

The course outlined below is designed primarily for pupils who will study science for only three years, and accordingly it is complete in itself. It also provides an adequate preparation for pupils who will continue the subject to the Scottish Leaving Certificate stage.

No attempt has been made to indicate the relative emphasis to be placed on the various parts of the syllabus; only the teacher can decide the prominence to be given to the different items. In making his decision he will naturally be influenced by the interests and industries of the community, but neither in industrial nor in rural areas should he allow these special considerations to dominate his schemes to such an extent as to make them vocational. Local interests should be used to initiate studies rather than to determine the nature of the course.

For convenience, the syllabus has been set out in branches, but it is not intended that these should be treated as separate and self-contained; for example, the study of water would combine physics, chemistry, and biology. Schools should construct their own schemes of work in accordance with this syllabus. These should show the teaching order to be followed, and the emphasis to be placed on the various items.

Physics

Qualitative treatment of thermal expansion of solids, liquids, and gases, including anomalous case of water; thermometry, including clinical thermometer. Change of state with simple ideas of latent heat. Experiments to bring out differences between measurement of heat and of temperature, and to establish that equal weights of different substances have different capacities for heat. Units of heat. Modes of heat transmission. Solution. Crystallization. Distillation. Conditions affecting evaporation. Simple determination of density. Pressure of liquids and gases. Barometers—mercury and aneroid. Principle of Archimedes and flotation. Direct reading hydrometers. Simple study of surface tension.

Moments, friction, machines (lever and block and tackle only).

Magnets. The compass. Magnetic induction. Simple and dry cells. Care and use of accumulator. Heating, chemical, and magnetic effects of a current. Current—potential difference—resistance; relation between them with simple calculations. Arrangements of cells and resistors. Electromagnet, electric bell, electric motor and generator. Easy household electrical repairs. Rating of houshold electrical applicances.

Rectilinear propagation of light, shadows, pin-hole camera. Laws of reflection. Refraction (qualitative treatment only). Converging and diverging lenses—effect on parallel beams. The eye as an optical instrument.

Production and transmission of sound. Echoes. Velocity in air. Pitch. Qualitative study of production of sound by strings. Examples of resonance.

Chemistry

Chemical change. Elements, compounds, mixtures. Atoms and molecules. Short study of air—composition—combustion and rusting.

Oxygen. Oxides. Acids and bases. Neutralization. Composition of water—analysis and synthesis. Hydrogen. Coal gas.

Qualitative study of carbonates and bicarbonates of calcium and sodium. Carbon dioxide. Hard and soft waters. Raising agents in baking.

Biology

Study of a typical flowering plant—structure (as seen by hand lens) and functions of parts.

Study of a mammal, e.g., rabbit, with reference to man—main bones, joints, muscular movement; position, appearance and functions of main organs; brief outline of nervous system.

The role of water in plant and animal life. Nutrition, respiration and reproduction in plants and animals. Dispersal of a few common fruits and seeds. Germination.

External features and life history of a protozoon, earthworm, butterfly, housefly or blowfly, fish, frog, bird.

Fieldwork during each season.

Notes on the Syllabus

PHYSICS

Determination of density should not figure prominently in any course.

In the teaching of hydrostatics, early opportunity should be taken to draw a clear distinction between force and pressure.

Some reference to calorific values of foods and fuels should be included when practical applications are being discussed.

In dealing with mechanics, every endeavour should be made to develop the subject in a realistic setting. The study of friction should stress the advantages and disadvantages of this force together with methods for increasing and decreasing it. Actual machines should be preferred to miniature models, and problems should be such as are likely to occur in practice. Useful guidance in the teaching of mechanics will be found in the Department's memorandum, "Technical Subjects in Secondary Schools".

In electricity, a direct treatment is envisaged, and considerable use will need to be made of ammeters and voltmeters. The inclusion of "Easy household electrical repairs" will provide opportunities for training the pupils in the precautions to be observed when dealing with power supplies.

Direct beam methods should be employed in the study of light.

CHEMISTRY

It is advisable for pupils to have some knowledge of the atomic nature of matter, and the idea of chemical formulae and equations may be introduced at least with the abler pupils.

Biology

To a considerable extent the treatment will be necessarily, and appropriately, seasonal. In no other branch of science teaching is forethought more essential. The teacher must plan to provide material for lessons days or weeks ahead. Teaching material should be drawn chiefly from living plants and animals. Charts and models, though useful supplements, are at best poor substitutes for actual specimens.

The special opportunity which biology affords in training powers of observation will be used to full advantage only if observations are made at first-hand; drawings should be made by the pupil with the minimum of aid from blackboard or text-book illustrations. Much time that is at present spent on the writing of long, dictated descriptions, would be better used in an unhurried examination of the plant or animal.

Experimental physiology should occupy a prominent place in every scheme. In practical work, simplicity, without loss of reliability, should be aimed at. The purpose of each experiment should be clearly stated, and care taken that it is not obscured by irrelevant detail. Experiments need not all be performed in the laboratory; some are more properly carried out in the open, e.g., in a school garden, where conditions approximate to those of a natural habitat. In dealing with human physiology, no opportunity should be lost of introducing simple experiments which the pupils can carry out on themselves, e.g., on circulation of the blood and respiration.

Everything possible should be done to encourage field studies.

DAVID HARE TRAINING COLLEGE * LIBRARY *

Science and the Backward Pupil

It has already been pointed out that schemes based on the foregoing syllabus will vary according to the intelligence levels of the pupils for whom the schemes are intended. When, however, the very low categories of intelligence are reached, change more drastic than mere modification of a general syllabus is clearly needed: experience shows that any attempt to teach traditional school science by traditional methods to backward pupils achieves little of real value. With the raising of the school leaving-age and the common adoption of the age-principle in determining promotion from primary to secondary education, the problem has assumed much greater urgency. It is, therefore, a matter of major concern that schools generally should make a fresh approach to the problem.

Although there is as yet no extensive fund of successful experience from which to draw specific guidance, there are several generally accepted principles which have a relevance to science teaching:

(i) Backward pupils have little ability to think in the abstract, and they are slow to profit from verbal instruction. Science teaching, by using to the full the opportunities it affords for study in the concrete, has an important part to play in the general education of these pupils.

(ii) Pupils of modest endowment show much more interest in particular than in general problems. Thus, for example, the challenge presented in getting a stiff lock to work easily is likely to meet with a ready response and to provoke profitable discussion, whereas anything approaching a formal, even though practical, lesson on friction may have a depressing rather than a stimulating effect.

(iii) The greatest interest is shown when the problem has an obvious link with the pupil's own personal experience. Facts about electrical conductors and insulators, for example, are more likely to be gleaned from working with pocket torches than from working with lengths of wire and unfamiliar cells.

(iv) Though backward pupils are not gifted on the intellectual plane, they are capable of deep feeling. Thus, some may show great fondness for animals or flowers. These interests, if fostered with sympathy and skill, may help to develop better attitudes to such diverse matters as personal and community hygiene, and the preservation of natural beauties.

(v) Backward pupils are able to concentrate for only a very short time. This has implications not only for the individual lesson, but also for the span of a series of lessons planned as a unit. A successful course might well consist of more or less isolated topics.

(vi) Since language difficulties are fundamental to the problem of backwardness, simple language should be used at all times.

Science teaching offers a useful opportunity for developing the powers of expression of backward pupils, since it can provide

Accessioned No. 121

first-hand experiences susceptible of simple description. The pupils should have regular practice in stating in their own words what they have done or observed. Much use should be made also of discussion methods in an endeavour to develop oral facility.

The pupils should be encouraged to make written records in a form commensurate with their ability: in these, pictorial description may often replace a verbal note. The pupils should not be set written tasks which in effect become mere exercises in transcription or dictation.

(vii) Every modern home has its complement of scientific appliances, e.g., pulleys, taps, cookers, radiators. Training in the handling of such devices in order to ensure safe and efficient working, and in the making of simple repairs, is a valuable preparation for all future citizens. It might well be a main objective in a course for backward pupils.

The teaching of backward pupils offers a challenge and an opportunity. Teachers should feel free to adopt any methods, however unconventional, which would give their pupils the joy and satisfaction of personal achievement.

Printed in Great Britain under the authority of HIS MAJESTY'S STATIONERY OFFICE
by Pickering & Inglis Ltd., Glasgow
Wt. 72243/112 K 40 12/50 Gp.559

Other Publications in this Series
prepared by the
Scottish Education Department

¶ *Primary Education*

THE PRIMARY SCHOOL IN SCOTLAND 2s. 6d. (2s. 8d.)

¶ *Secondary Education*

The following are booklets on the various subjects of the curriculum in Scottish Secondary Schools

MATHEMATICS	1s.	(1s. 2d.)
MODERN LANGUAGES	1s. 3d.	(1s. 5d.)
TECHNICAL SUBJECTS	1s. 9d.	(1s. 11d.)
TECHNICAL SUBJECTS (ROOMS, EQUIPMENT AND SAFETY PRECAUTIONS) ..	1s.	(1s. 2d.)
CLASSICS	.. In the Press	
GEOGRAPHY		
ENGLISH		
ART		
HOMECRAFT		
COMMERCIAL SUBJECTS ..		

Booklets on further subjects are in course of preparation

Prices in brackets include postage

Obtainable from

HIS MAJESTY'S STATIONERY OFFICE
13A CASTLE STREET · EDINBURGH 2

and at Sales Offices in London, Manchester
Birmingham, Cardiff, Bristol and Belfast

OR THROUGH ANY BOOKSELLER

371·3
SCO

100

Crown Copyright Reserved

PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

To be purchased from
13a Castle Street, EDINBURGH, 2
429 Oxford Street, LONDON, W.1
39 King Street, MANCHESTER, 2
2 Edmund Street, BIRMINGHAM, 3
York House, Kingsway, LONDON, W.C.2
1 St. Andrew's Crescent, CARDIFF
Tower Lane, BRISTOL, 1
80 Chichester Street, BELFAST
or from any Bookseller

1951

Price 9*d*. net

BOOK
OF
UTTA
W DELHI

S.O. Code No. 30-102